Buildings and Critical Facilities Performance

Mark Pierepiekarz, PE, SE

President, MRP Engineering
Newcastle, WA
425/430-0500
mrp@mrpengineering.com

Past President, Structural Engineers Association of Washington
Seattle Chapter

Introduction and Purpose

- Intent of the scenario study was to:
  - Increase awareness of a real threat
  - Start (or continue) a conversation
  - Have some public policy debate
  - Increase our region's preparedness
- Develop recommendations and impetus for effective actions to protect:
  - Lives
  - Critical facilities
  - Key infrastructure

Pre-Scenario Perceptions

Two 2001 Nisqually EQ studies conclusions:

- Small Business:
  - 20% physical loss, 60% lost productivity.
  - Only 1 in 3 increased preparedness afterward.
- Households:
  - Before – less than half took steps to prepare.
  - 300,000 damaged by EQ.
    - 1 in 4 experienced loss, averaging $622 to $1,350.
  - Only 1 in 5 increased preparedness afterward.
- Perceptions:
  - We faced the “big one” and it wasn’t so bad…
  - Some of the “careful” became more “careful.”

Katrina: Critical Services and Schools

Katrina: Small Businesses and Housing

Post-Katrina Recovery Pace in Louisiana

Item	Pre-Katrina	February 26, 2006 (% decrease)
Population		
Orleans Parish	462,269	189,000 (59%)
St. Bernard Parish	65,554	12,000 (82%)
Metro Labor Force	633,759	428,229 (32%)
Restaurants (Metro)	6,745	2,476 (63%)
Public Schools Orleans Parish	64,270	9,298 (86%)

Sources: The Times-Picayune, State of Louisiana

Scenario Damage Estimates

- Very strong ground motions near the fault
- 4,000 (27%) commercial structures with significant damage:
  - Unreinforced masonry (URM's)
  - Reinforced concrete Tilt-ups
  - Pre 1970-vintage reinforced concrete frame buildings
- Significant damage to structures founded on poorly consolidated soils
- 46,000+ households displaced
- Long-term impact on industry and economy

Building Codes History

The intent of earthquake design provisions in building codes for new construction is safeguarding human life, not damage prevention.

Year	Building Code Development (for new construction)
1894	First building code published for Seattle
1946	Earthquake requirements added to Seattle building Code
1953	Earthquake design level increased in the Seattle following the 1949 Olympia earthquake
1955	State law mandates earthquake design for newly constructed hospitals, schools, assembly, and public buildings in Western Washington
1974	1973 Uniform Building Code made the minimum standard throughout the state
2004	The 2003 edition of the International Building Code adopted by the State Building Code Council

Most seismic retrofits are currently voluntary.
There is currently no requirement for seismic retrofit of existing vulnerable buildings, unless significant renovation is proposed.

Local Building Stock

Local Building Stock

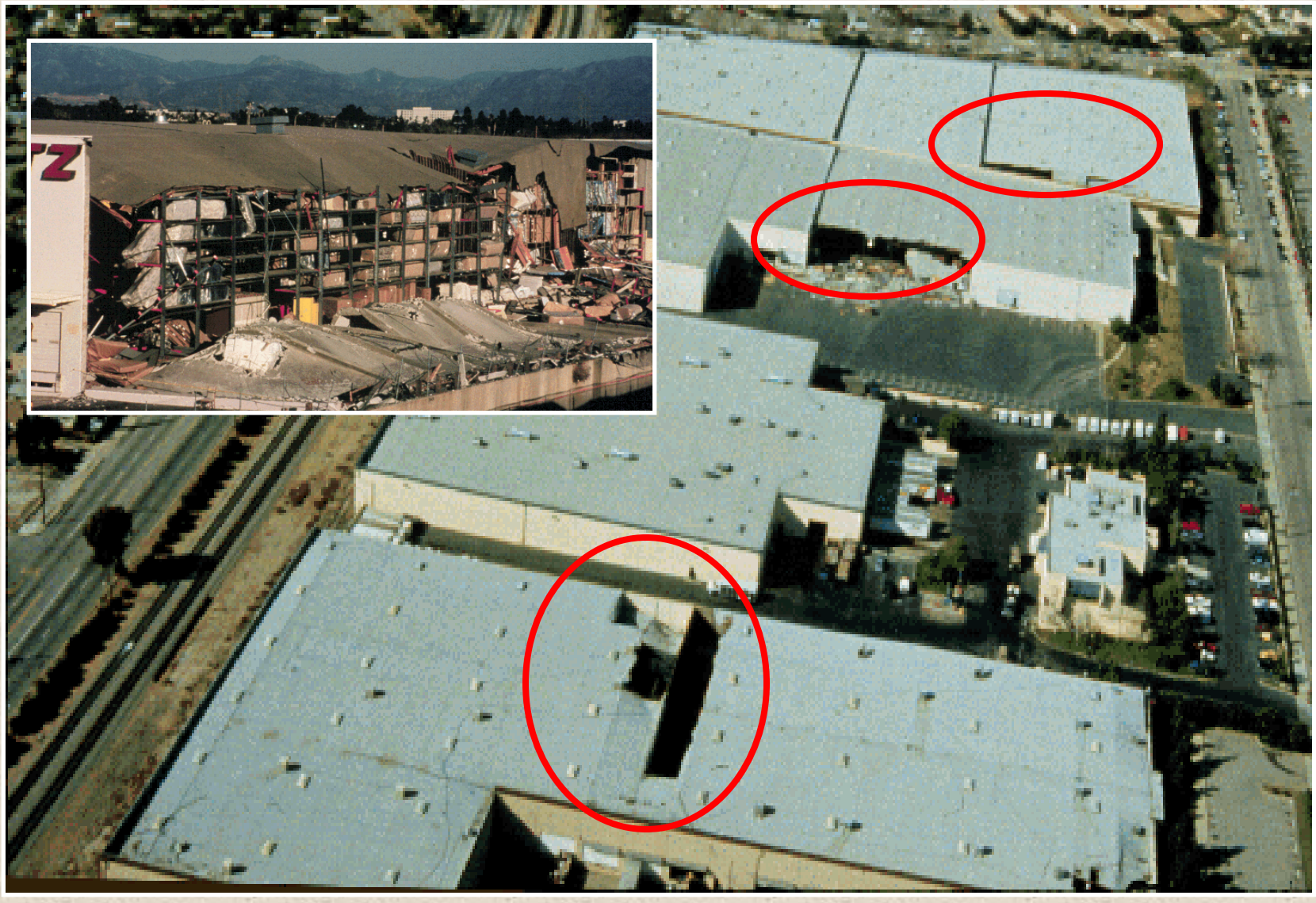
E.Q. Performance Factors

- Type of system (tilt-up, pre-cast, shear wall)
- Primary material (steel, concrete, wood)
- Year designed/built (year and code)
- Type of soil (soft soil vs. rock)
- Layout
  - Geometry (Rectangular, L-shaped)
  - Openings above grade (windows/garages)
- Quality of design and construction

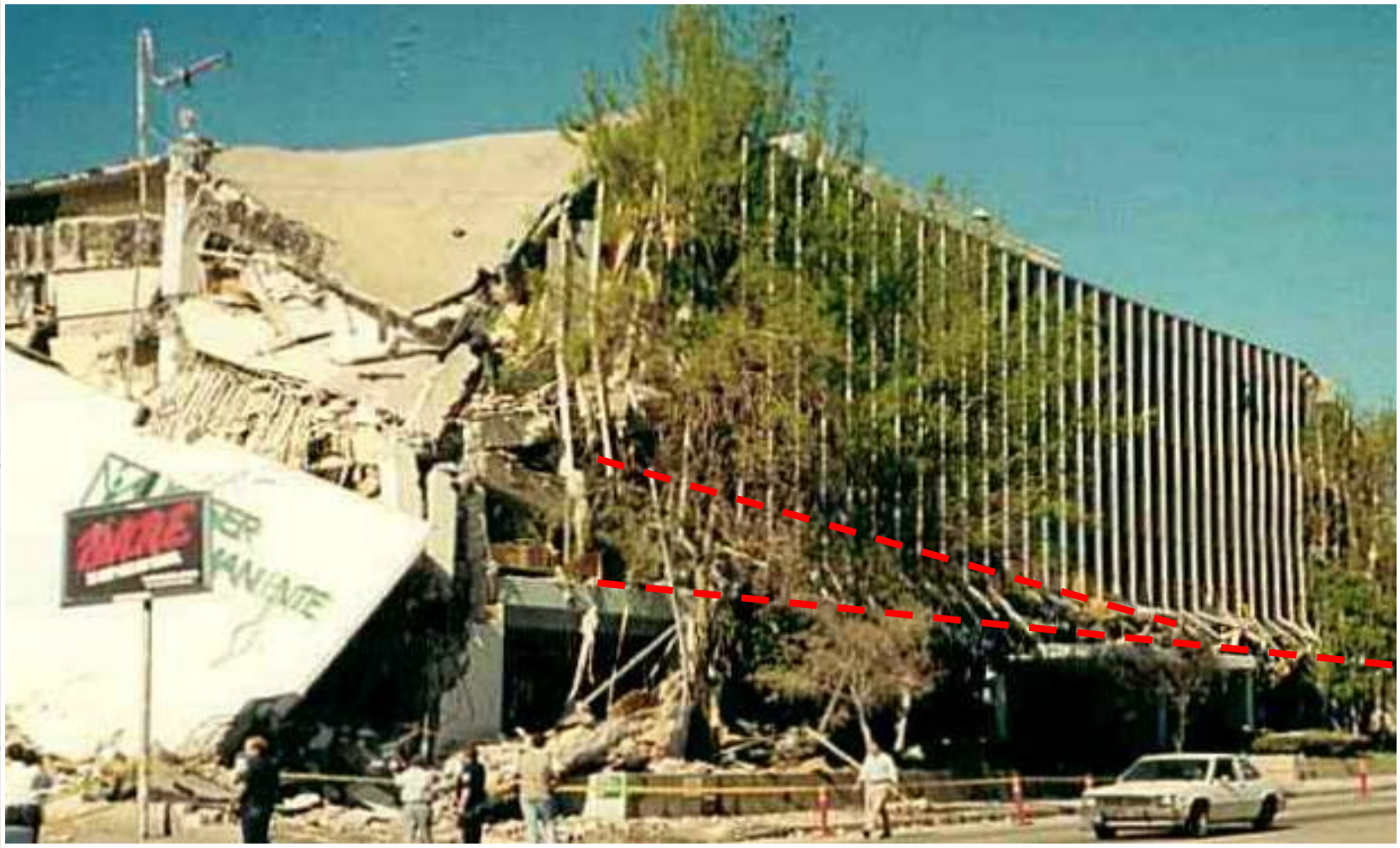
Unreinforced Masonry (URM's)

Retrofitted URM Building

Tilt-Up Concrete Buildings



Concrete Structures



The collapse occurred in an unoccupied building at about 5 AM.
At noon this medical office building would have been full of people.

HAZUS Projections: Household Loss of Occupancy

% of Displaced Households	Time to Reoccupy
50% to 60%	2 Weeks
25% to 35%	Less than 3 months
15%	More then 6 months

Building Performance Summary

- Scenario ground motions significantly greater than in recent earthquakes.
- Modern structures would survive with varying degrees of damage.
- Many older existing structures would experience significant damage with some collapses.
- Organizations should assess potential risks and make practical improvements.

Sample Risk Assessment Loss Summary

	Value	Existing		Retrofitted	
Buildings	100^{M}	30%	30^{M}	15%	15^{M}
Equipment	100^{M}	20%	20^{M}	10%	10^{M}
Time Element	200^{M}	6 Mo	100^{M}	3 Mo	50^{M}
Total	400^{M}	150^{M}		75^{M}	

An engineering risk assessment includes prioritized recommendations to limit damage and downtime in addition to loss data.

Nonstructural Bracing

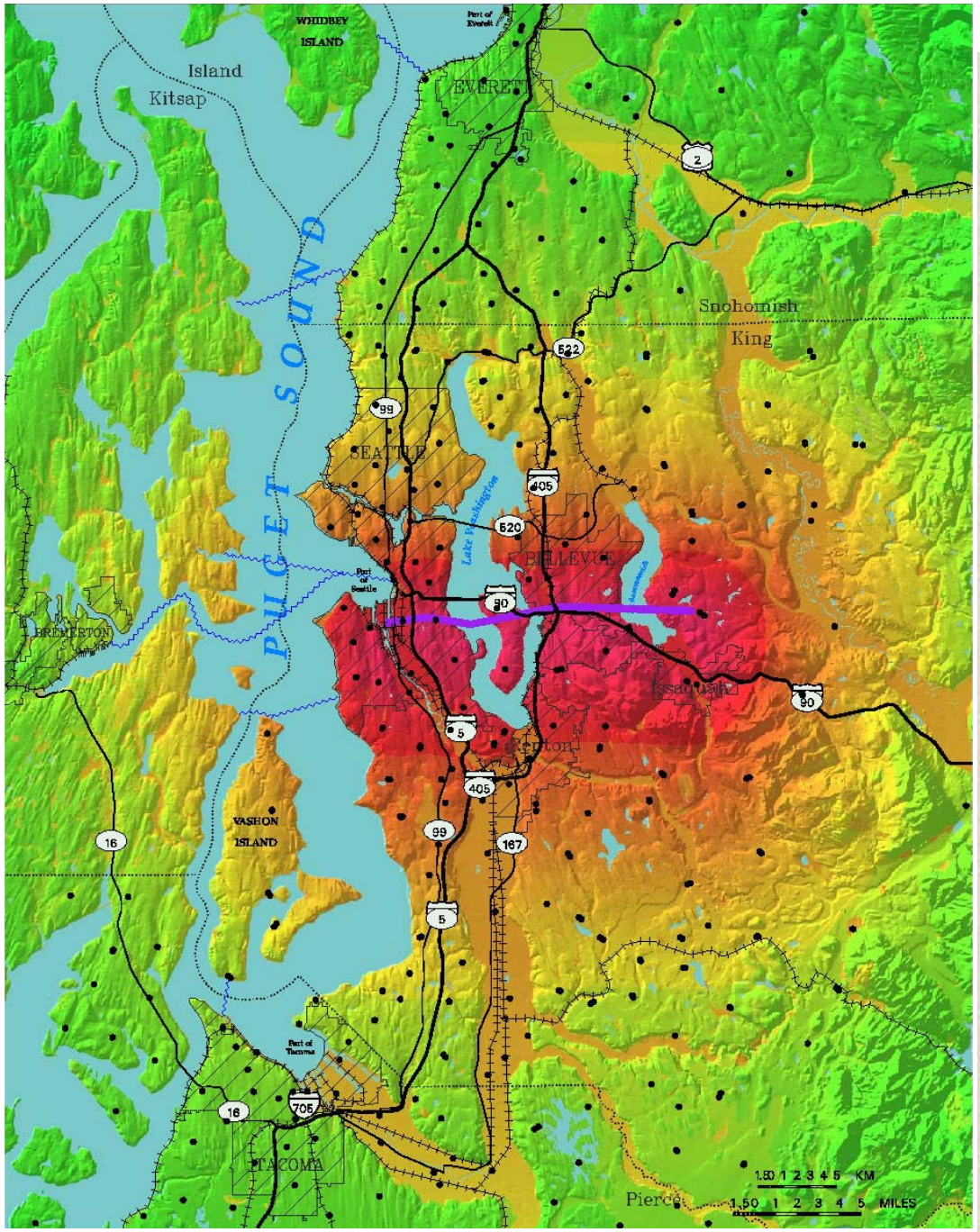
Hospital Damage Projections

Table 6-1: Estimate of Number of Available Hospital Beds at Various Time Periods Following Event

Time After Event	King County (4,400 Total Beds)		Pierce County (1,400 Total Beds)		Snohomish County (500 Total Beds)	
	# Beds Available	% Beds Available	# Beds Available	% Beds Available	# Beds Available	% Beds Available
1 Day	1,100	25%	1,110	79%	380	76%
3 Days	1,370	31%	1,160	83%	400	80%
7 Days	1,720	39%	1,230	88%	420	84%
30 Days	2,910	66%	1,340	96%	480	96%
90 Days	3,470	79%	1,390	99%	490	99%

Overview of Fire Stations

- Over 350 fire stations in region
- Distribution proportionate to population
- Vary in size and construction type
- Unique features include bay doors and hose towers



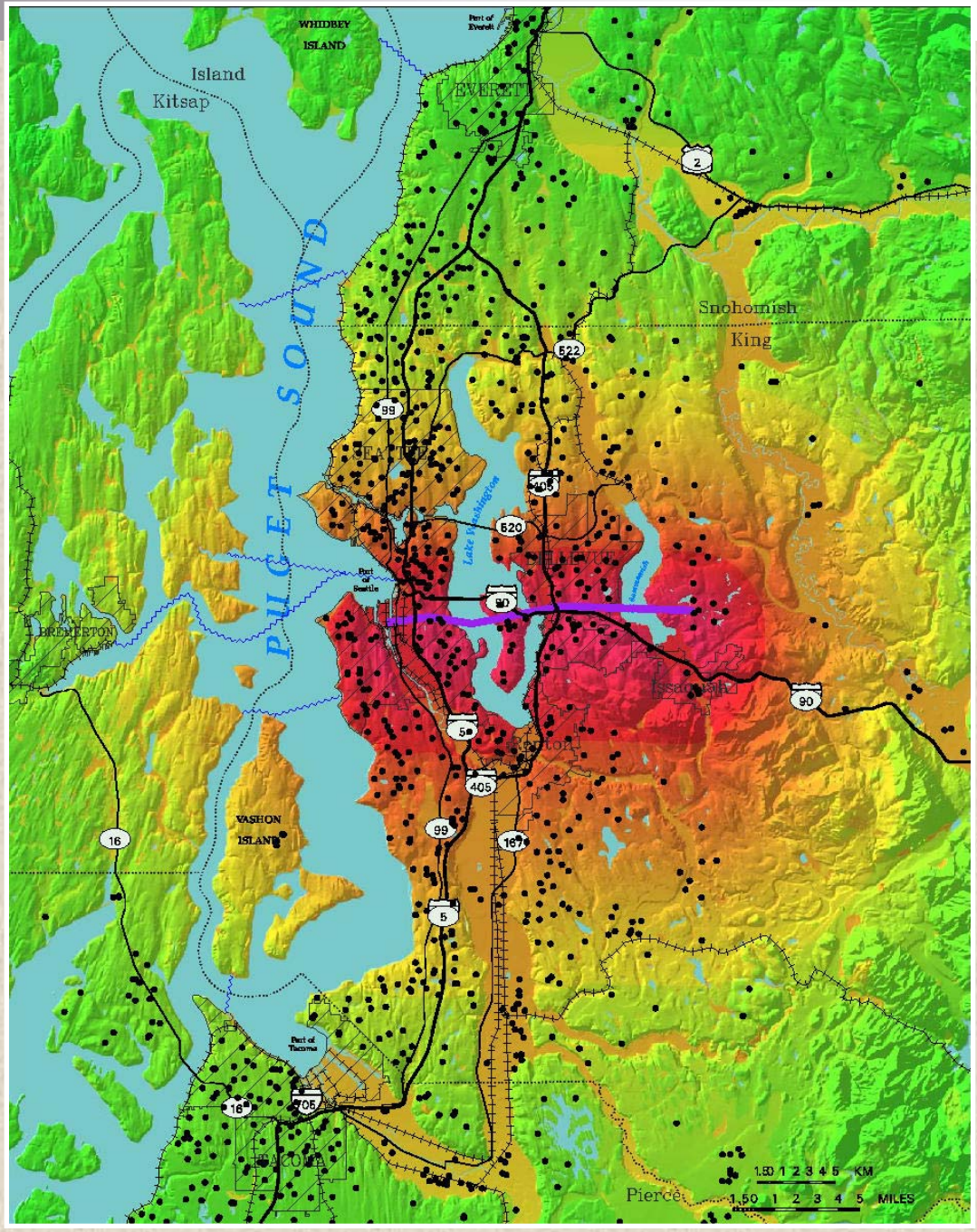
Fire Station Damage Projections

Table 6-2: Projected Damage to Fire Stations

Peak Ground Acceleration	% of Stations with Reduced Functionality	% of Stations Not Useable
Greater than 0.75g	More than 70%	20% to 30%
Between 0.45g and 0.75g	60% to 70%	10% to 20%
Between 0.30g and 0.45g	30% to 40%	Less than 10%
Between 0.15g and 0.30g	10% to 20%	Less than 5%
Less than 0.15g	Less than 10%	0%

Overview of Schools

- Over 1,200 schools and campuses in region
- Wide range of construction materials and age
- Some level of upgrade completed but not well documented as a region



School Damage Projections

Table 6-3: Expected Damage to Schools

County	Damage (in percent)				
	No Damage	Slight	Moderate	Extensive	Complete
King County	23%	22%	29%	18%	8%
Pierce	64%	18%	12%	5%	1%
Snohomish	64%	14%	9%	3%	10%
Total Region	38%	20%	22%	13%	7%

School Impacts and Recovery Issues

- Immediate issue of how to care for thousands of children while parents try to reach them.
- Intermediate and long-term issues with where to house students to continue education and allow parents to return to work.
- Local governments may place a higher priority on repair of schools.

Conclusions and Actions

- Washington State is behind other West Coast region in earthquake risk mitigation.
- Scenario report succeeded in focusing attention on the issues
- Pre-active actions are conducted on a voluntary basis only.
- Requirements and incentives for mitigation remain a regional goal.